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# Collaborative Biodiesel Emissions Test (CBET) Program

An Overview for Steering Committee  
Members

April 5, 2007

# Program Objective

Conduct a scientific study to determine the impact of biodiesel on exhaust emissions from diesel engines

- Assess impacts of key factors:
  - Engine technology
  - Engine load / test cycle
  - Biodiesel feedstock / content
  - Base fuel properties
- Engage a broad spectrum of stakeholders
- Coordinate with CARB to ensure compatibility and synergy between CBET Program and proposed CARB Biodiesel Emissions Study

# Background

- NBB letter to Administrator Johnson (Nov. 2006) committed to support and fund a biodiesel emissions test program, developed with interested stakeholders
- Convened first meeting of stakeholders on January 25
  - Participants: NBB, EMA, AAM/AIAM, API, CRC, EPA, CARB, DOE, NREL, Texas CEQ, Biodiesel Coalition of TX, Houston Advanced Research Coalition
  - Strong support for moving forward with test program
  - General indication of funding support from many key stakeholders
  - Recommendations:
    - Form Steering Committee to guide general direction of program and secure funding
    - Form Technical Subcommittee to develop detailed test program

## Background (Cont'd)

- Convened Technical Subcommittee meetings Feb. 21 and March 13
  - Participants: NBB, EMA, AAM/AIAM, API, CRC, EPA, CARB, NREL, Texas CEQ
  - As discussions progressed, the draft technical program grew excessively to accommodate stakeholders' interests (e.g., base fuels, biodiesels, blend levels)
    - The unabridged version was deemed unmanageable by vast majority of stakeholders
  - An optimized, pared down version of the technical program was eventually developed
  - Participants recommended that both the optimized and unabridged versions be presented to the Steering Committee for final decision
- CRC interested in providing oversight/support to CBET Program
  - CRC board very supportive to fill whatever role is most effective
  - CRC involvement requires prior review and approval of technical program by CRC Emissions Committee

# Where we are

- Technical Subcommittee has defined two versions of the technical program
- Next steps:
  - Convene Steering Committee meeting
    - Finalize technical program design
  - Secure funding commitments from key stakeholders
  - Secure CRC involvement in CBET Program
  - Launch CBET Program
- Proposed Steering Committee Membership:
  - EPA Chair (potential CRC co-chair)
  - NBB, Biodiesel Coalition of Texas
  - EMA, AAM, AIAM, API
  - DOE, NREL
  - CARB, TCEQ
  - CRC

# “Optimized” Technical Program

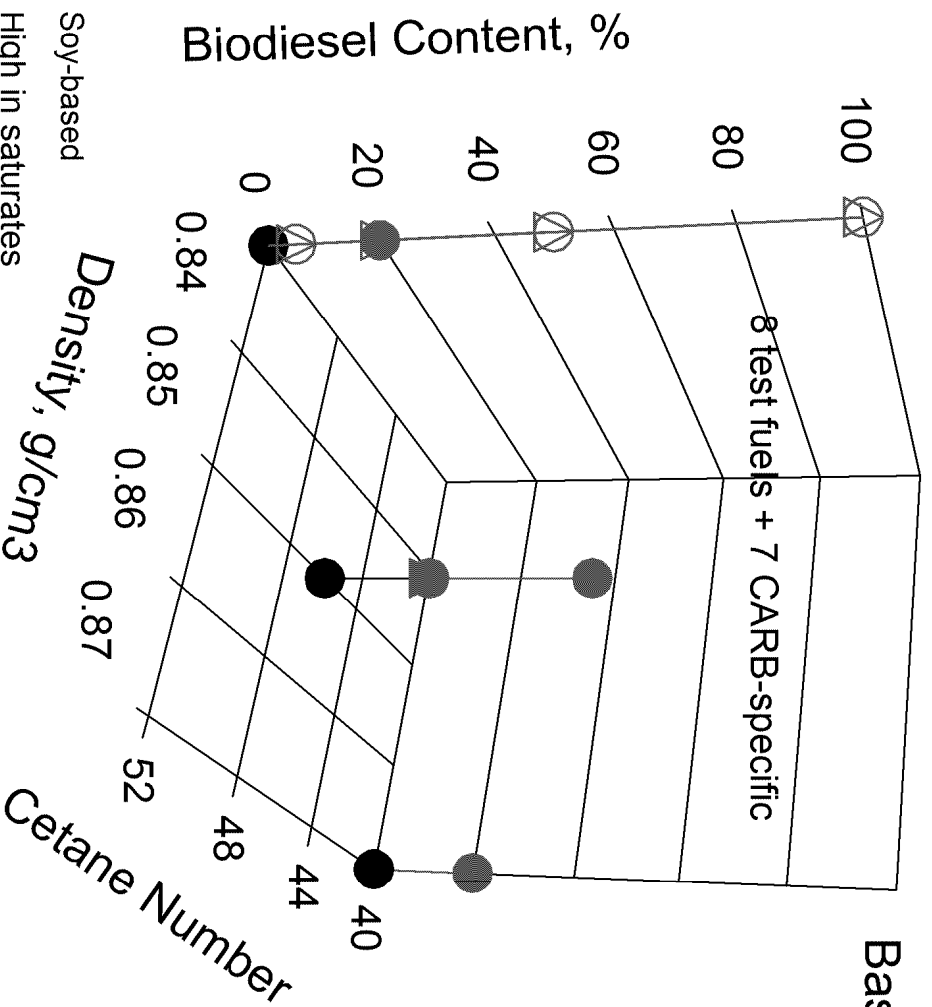
- Stakeholder input was extensively used in the process of designing the technical program
- Results of recent NVFEL engine tests also played an important role in shaping the program
  - Redefined the way biodiesel impact on NOx is assessed
  - Helped advance understanding of biodiesel impacts on emissions
- The following “optimized” version of the technical program was defined during the March 13 meeting of the Technical Subcommittee:
  - Number of test engines/vehicles (*Based on statistical analysis of NVFEL and NREL emissions test data*)
    - 18 highway engines (3 of these engines will also be tested by CARB)
    - 3 nonroad engines
    - 3 LD vehicles
  - 4 additional vehicles will be tested by CARB using a subset of fuels

# “Optimized” Technical Program (Cont’d)

- Number of test engines/vehicles (Cont’d)
  - Focus on 1994 – 2007 MY engines
    - 2010+ technology prototypes may not be available for testing or representative of future production
  - 3 advanced technology LD vehicles will be tested by their manufacturers
  - CARB test vehicles may span a broader MY range
- Engine test cycles and test replicates
  - Four hot, transient cycles will be used, including FTP
  - 3-4 test replicates on each test cycle required to achieve statistical significance
  - Test cycle selection is being coordinated with CARB
- Vehicle test cycles and test replicates
  - Vehicle test cycles and the number of test replicates will be established in cooperation with AAM and CARB



# “Optimized” Fuel Matrix



Base fuel property range:

- Density: 0.83 – 0.87 g/cm<sup>3</sup>
- Cetane number: 40 - 52
- Monoaromatics: 18 – 31%
- Polyaromatics: 2 - 9%
- Total Aromatics: 20 – 40%
- T90: 590 – 610 °F
- Base fuel property range will be updated based on winter 2006/2007 diesel fuel surveys



Soy-based  
High in saturates  
Base fuel  
Soy-based, tested in CARB engines/vehicles only  
High in saturates, tested in CARB engines/vehicles only

# “Optimized” Technical Program (Cont’d)

- Base fuels
  - Three ULSD base fuels spanning cetane number and density/aromatic content range of U.S. market fuels
  - Down from six fuels originally proposed by the EPA
    - Stakeholders argued that test program should be reduced to manageable size
  - One of the base fuels will be a “typical” CARB diesel fuel
- Biodiesels
  - Two types of biodiesels spanning broad range of ester compositions/properties
    - High in unsaturates (soy-derived)
    - High in saturates (e.g. animal fat-derived)
  - Down from three biodiesels originally proposed by stakeholders
    - Soy derived biodiesel dominates U.S. market
    - Second biodiesel will enable interpolation w/o excessively enlarging the test program
  - Additional biodiesel(s) may be tested by CARB in three engines and four vehicles

# “Optimized” Technical Program (Cont’d)

- Biodiesel content levels
  - Focus on B20
    - B10 fuels eliminated from the test matrix due to their disproportionate effect on cost of the technical program
    - Instead, linearity of biodiesel impacts on NOx emissions below B20 may be determined in a limited scope study, such as the following:
      - » Number of test engines: 1
      - » MY of test engine: 2002 - 2006
      - » Test cycle: High load cycle, such as HWY55, to increase the likelihood of achieving statistically significant results for the least amount of testing
      - » Base fuel: ULS “average” US diesel fuel
      - » Biodiesel: Soy-derived
      - » Biodiesel content levels investigated: B5, B10 and B20
      - » Estimated cost: \$70,000
      - » If significant nonlinearity is observed, additional testing can be added
- B5, B20, B50 and B100 fuels will be tested by CARB in 3 engines and 4 vehicles

# “Optimized” Technical Program (Cont’d)

- Test fuels
  - Eight fuels tested in all engines and three LD vehicles
  - Seven additional fuels tested by CARB in three engines and four additional vehicles

“Optimized” Program Cost Estimate

Program	Test Engines/Vehicles	Number of Engines/ Vehicles	Cost of Exhaust Emission Testing, \$M	Cost of Unregulated Emission Measurements, \$M	Fuel Cost, \$M	Statistical Analysis, \$M	Engine and Vehicle Cost, \$M	Total, \$M
Base	Engines (includes 3 nonroad)	<div>EX. 4 - CBI</div>						
	LD Vehicles							
	Engines							
CARB	Vehicles							
		Grand Total:						
		5.11						

# Funding for “Optimized” Program

Stakeholder	Cash Contributions, \$M	In-Kind Contributions, \$M	Total Contributions, \$M
EPA**			
NBB			
CARB			
EMA			
AAM			
API			
All Stakeholders	0	0	0

Total Needed:	5.11
Shortfall:	(5.11)

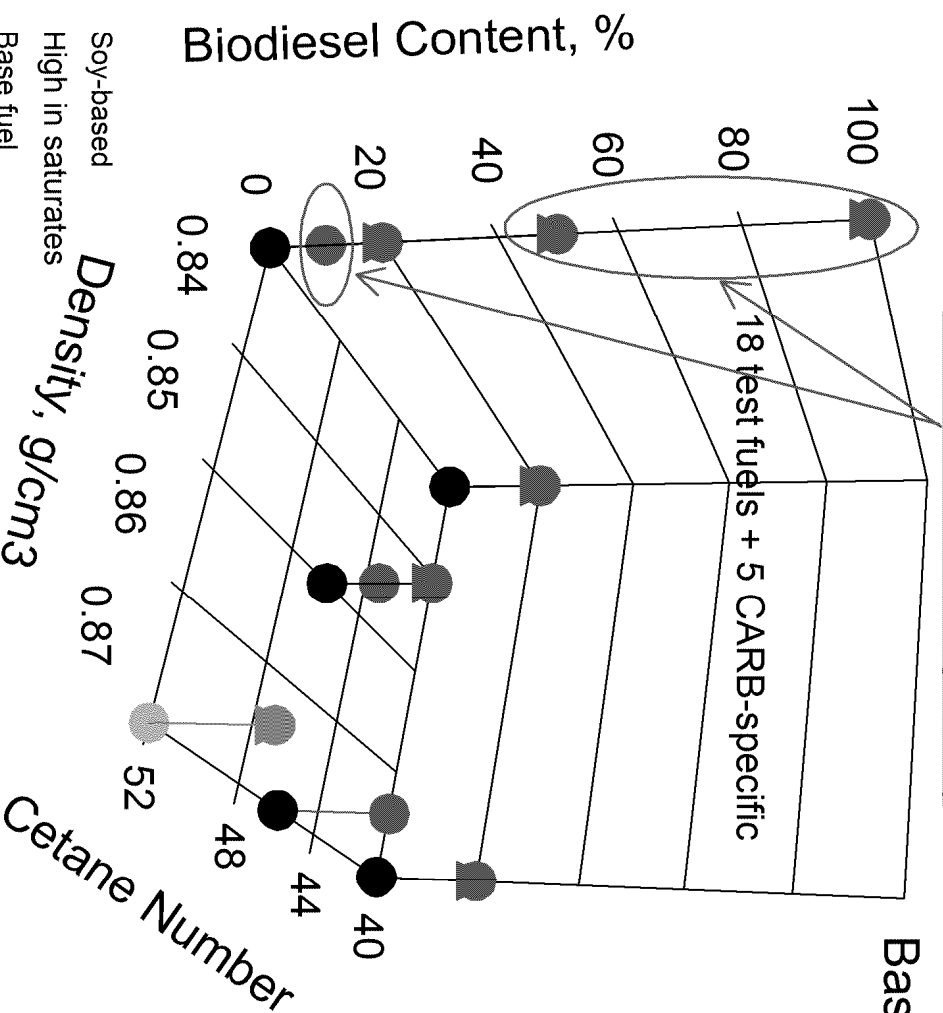
\*\* EPA testing 3 engines

# “Unabridged” Technical Program

- Differences from “Optimized” Technical Program
  - Includes an expanded fuel matrix:
    - Three more base fuels, including one cetane boosted fuel
    - Two B10 blends
  - Does not include the B50 blend based on “average” U.S. diesel fuel

# “Unabridged” Fuel Matrix

Fuels tested in CARB engines only



Base fuel property range:

- Density: 0.83 – 0.87 g/cm<sup>3</sup>
- Cetane number: 40 - 52
- Monoaromatics: 18 – 31%
- Polyaromatics: 2 - 9%
- Total Aromatics: 20 – 40%
- T90: 590 – 610 °F
- Base fuel property range will be updated based on winter 2006/2007 diesel fuel surveys



“Unabridged” Program Cost Estimate

Program	Test Engines/Vehicles	Number of Engines/ Vehicles	Cost of Exhaust Emission Testing, \$M	Cost of Unregulated Emission Measurements, \$M	Fuel Cost, \$M	Statistical Analysis, \$M	Engine and Vehicle Cost, \$M	Total, \$M
Base	Engines (includes 3 nonroad)	21	<b>EX. 4 - CBI</b>					
	LD Vehicles	3						
	Engines	3						
CARB	Vehicles	4						
Grand Total:								10.67

# Funding for “Unabridged” Program

Stakeholder	Cash Contributions, \$M	In-Kind Contributions, \$M	Total Contributions, \$M
EPA			
NBB			
CARB			
EMA			
AAM			
API			
All Stakeholders	0	0	0

Total Needed: 10.67

Shortfall: (10.67)